MONTHLY WEATHER REVIEW

Editor, James E. Caskey, Jr.

VOL. 77, No. 1
W. B. No. 1535

JANUARY 1949

CLOSED MARCH 5, 1949
ISSUED APRIL 15, 1949

COLUMBIA RIVER BASIN FLOOD

MAY–JUNE 1948

ELMER R. NELSON

[U. S. Weather Bureau, Washington, D. C.]

Manuscript received December 14, 1948

INTRODUCTION

The spring flood of 1948 in the Columbia River Basin caused the greatest destruction of record, with the loss of more than a score of lives and property damage estimated at more than 100 million dollars. It was second only to the flood of 1894 in volume of water.

The flood waters remained above critical flood stage for a long period, adding considerably to the damage. At Vancouver, Wash., the peak discharge was slightly over a million cubic feet per second and flow continued at nearly that rate for over two weeks. Because of the rapid initial rise and the long-continued pressure at near peak stages, there were many dike failures.

Some flooding occurs in the lowlands adjacent to the Columbia River and its important tributaries every year, but the frequency of extreme floods, such as the one of 1948, is quite low since a combination of several factors is necessary to produce a general flood of such extreme nature.

A heavy late-season accumulation of snow melted slowly in the early spring because of cold weather. Temperatures rose rapidly when warm weather finally arrived and, remaining high, resulted in very rapid late season melting. Unusually heavy rains swelled the rivers. In the upper Columbia Basin, the major tributaries reached crests within a period of 5 days. In the lower Snake River the crest was several weeks later than normal and therefore played a greater part than usual in raising the crest on the lower Columbia.

This paper presents a discussion of this destructive flood and the meteorological conditions over the Columbia Basin in the winter and spring of 1948 which, together with the general topography of the region, served to produce it.

DESCRIPTION OF BASIN

The Columbia River Basin, draining an area of 245,000 square miles, is the second largest in this country, being exceeded only by the Mississippi River System. In size it is slightly larger than the Colorado or the Ohio River Basin. Its average annual discharge is about 200,000 cubic feet per second (about 20 percent less than that of the Ohio) and its record peak flow (1894) is about 1,200,000 cubic feet per second, or about 40 percent less than that of the Ohio. In such a comparison, the Colorado River ranks very low, with average daily discharge of about 25,000 cubic feet per second (10 percent of the Columbia) and a record peak flow about 25 percent of that of the Columbia River.

A brief description of the topographical and climatological features of this large basin helps in the interpretation of the conditions which produced the flood.

TOPOGRAPHY

The Columbia River drains the area between the Cascade Mountains on the west and the Continental Divide on the east. Fig. 1 shows that the basin extends southward to the borders of California, Nevada, and Utah and northward into southeastern British Columbia, draining an area of nearly 40,000 square miles in Canada.

For purposes of this discussion the Columbia Basin is divided into three main subdivisions: The upper Columbia (above the Snake), the Snake River, and the lower Columbia (below the Snake).

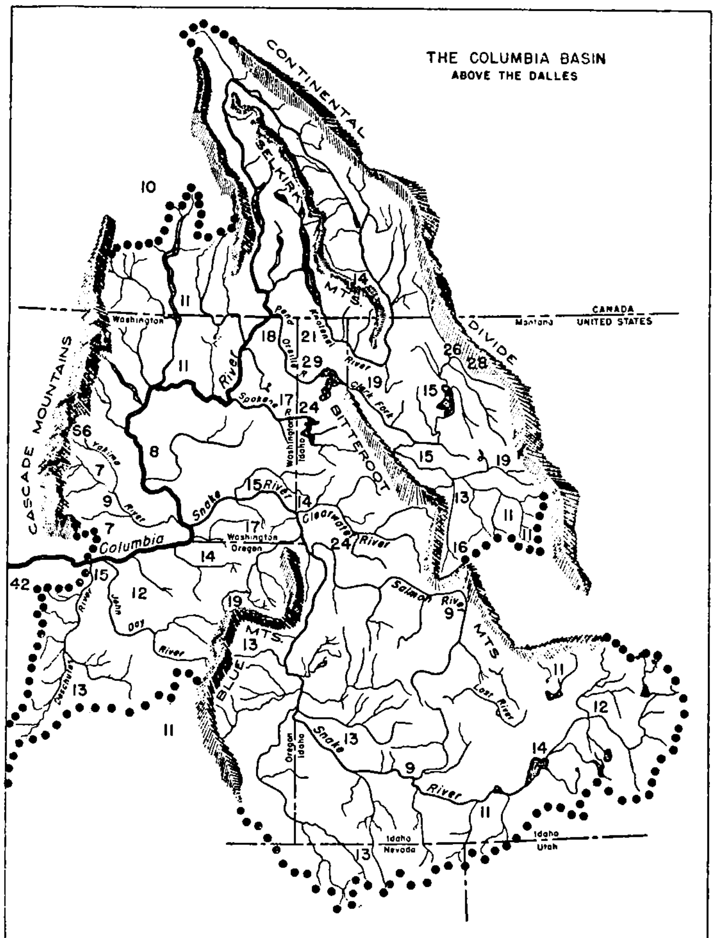


FIGURE 1.—Map showing principal topographical features of the Columbia Basin above The Dalles. Numbers represent average annual precipitation in inches.

The upper Columbia River Basin is composed of three main drainage basins: The main Columbia, the Kootenai, and the Clark Fork-Pend Oreille. The main stem of the upper Columbia runs northwestward in southeastern British Columbia between the Rocky Mountains (6,000 to 13,000 feet) and the Selkirk Mountains (4,000 to 12,000 feet) and then turns abruptly southward toward the United States border. In its southward journey the main stream drains the west slopes of the Selkirks and the east slopes of the Monashee Mountains. The topography along the Columbia in Canada is very rugged and this area has high winter precipitation. There are no important tributaries above the confluence with the Kootenai River. The Kootenai also has its headwaters between the Rockies and the Selkirks. It parallels the main stem but flows south-southeastward approximately 190 miles from its source to the United States border. After flowing through northwestern Montana and northern Idaho for about 120 miles, it reenters Canada to join the main course of the Columbia 30 miles north of the Washington border. The Kootenai runs through the same type of rugged narrow drainage area of high winter precipitation as the Columbia and also has no important tributaries. The Clark Fork-Pend Oreille River system flows into the Columbia in Canada just north of Boundary, Wash. It drains the area in Montana between the Continental Divide and the Bitterroot Mountains, an area less rugged than that of the Kootenai and the main stream, but with elevations of 7,000 to 10,000 feet. The main Columbia from Grand Coulee, Wash., to the confluence with the Snake River has no tributary of major importance. The area to the east of the river is mostly semiarid desert, while from the west small streams drain into the Columbia from the eastern slopes of the Cascade Range, whose elevations vary from 4,000 to 7,000 feet. The annual precipitation at the higher elevations of the eastern slopes of the Cascades amounts to 60 inches or more, but decreases rapidly to 20 inches or less before the Columbia River is reached. Areas immediately to the east of the Columbia receive less than 10 inches, but precipitation increases again to 30 or 40 inches or more on the western slopes of the Bitterroots and the Rockies.

The Snake River empties into the Columbia below Pasco, Wash. It drains a triangular area bounded on the northeast by the Bitterroots and the Continental Divide and on the west by the Blue Mountains extending southward to the borders of Nevada and Utah. It flows westward from the Continental Divide in northwestern Wyoming to the south of the arid region in southern Idaho, then northward along the western border of Idaho. The headwaters area in Wyoming and eastern Idaho is rugged and receives high precipitation. The Snake flows across southern Idaho, without a major tributary, until it is joined by the Boise and Payette Rivers in the vicinity of Boise, Idaho. From this point the Snake flows through a very deep canyon to below Lewiston, Idaho, where it is joined by its major tributary, the Salmon River. This tributary drains the rugged west slopes of the Bitterroot Mountains, which run northwest-southeast along the northeastern border of Idaho. North of the headwaters of the Salmon, the Bitterroot Mountains are drained by the Clearwater River, which joins the Snake at Lewiston. Except for the arid area in southeastern Idaho, the Snake drains an area which is very rugged and varies greatly in precipitation amounts.

The lower Columbia, below the confluence of the Snake, flows generally westward through a deep gorge in the Cascade Mountains. The only tributary of any size to join the lower Columbia is the Willamette River from the south at Portland, Oreg.

CLIMATOLOGY

The climate of the Columbia River Basin is determined primarily by its location within the zone of the prevailing westerlies and its proximity to an oceanic moisture source. There are striking climatic variations within the basin, however, which are explained by the topography of the region. The region is meteorologically dominated by the activities of the Aleutian Low and the Pacific High. These centers of action, with mean positions at about latitudes of 55° N. and 35° N., respectively, exhibit an annual migration associated with the march of solar altitude, centering farthest north in summer and farthest south in winter. Accompanying this migration, with the seasonal variation in contrast between land and sea temperatures providing a major cause, is the growth in intensity and extent of the Aleutian Low in winter and the simultaneous weakening of the Pacific High. Thus the basin comes within the influence of the Aleutian Low's circulation at the time of its greatest extent and intensity, with the result that the basin is then exposed to frequent cyclonic and frontal passages imbedded in the prevailing eastward or northeastward moving current of maritime air. Normally this moisture-laden air would deposit most of its moisture on the western slopes of the coastal mountains with less and less precipitation falling over the interior valleys as the air mass moves farther and farther from its source of moisture. However, in the winter season when the circulation of the Aleutian Low is most vigorous not only is the intensity of precipitation increased along the western slopes of the Coastal and Cascade Ranges, but also the normally lower intensities in the interior basins constituting the Columbia River system may be increased by temporary variations in such factors as carry-over, direction of flow, frontal passages, and instability. Thus the major portion of the annual precipitation over the basin is accumulated during the period from October to June, the maximum monthly average occurring in December. Figure 1 shows the average annual precipitation at selected stations in the Columbia Basin.

Because of the comparatively steep lapse rates in the cool maritime air, a high percentage of this precipitation falls as snow. This snow accumulates in packs of considerable depths at high elevations, with the water stored until the snow is melted during the spring thaws. As a result, a large portion of the Basin's annual precipitation is made available to the river in this spring period. If this accumulation is high, and it is melted rapidly by unusually high temperatures, high flows will result.

Normally, snow melt begins first in the southern portion of the Basin (Snake), progressing slowly northward with the runoff from southern tributaries passing out to sea before the arrival of the upper Columbia crest. If melting takes place simultaneously over the entire basin the total runoff will be increased enormously. If heavy rains occur at the same time, the possibilities of a major flood will be almost a certainty.

The conditions prerequisite to a major flood in the Columbia Basin are therefore:

1. Abnormally high accumulation of snow in the basin. This results from excessive precipitation plus abnormally low temperatures.
2. A period of excessively high spring temperatures over the entire basin.
3. Heavy rains coincident with the high temperatures.

This combination of events must develop in sequence over a period of about 6 months. Its probability is very small and consequently the frequency of extreme floods in the Columbia Basin is very low.

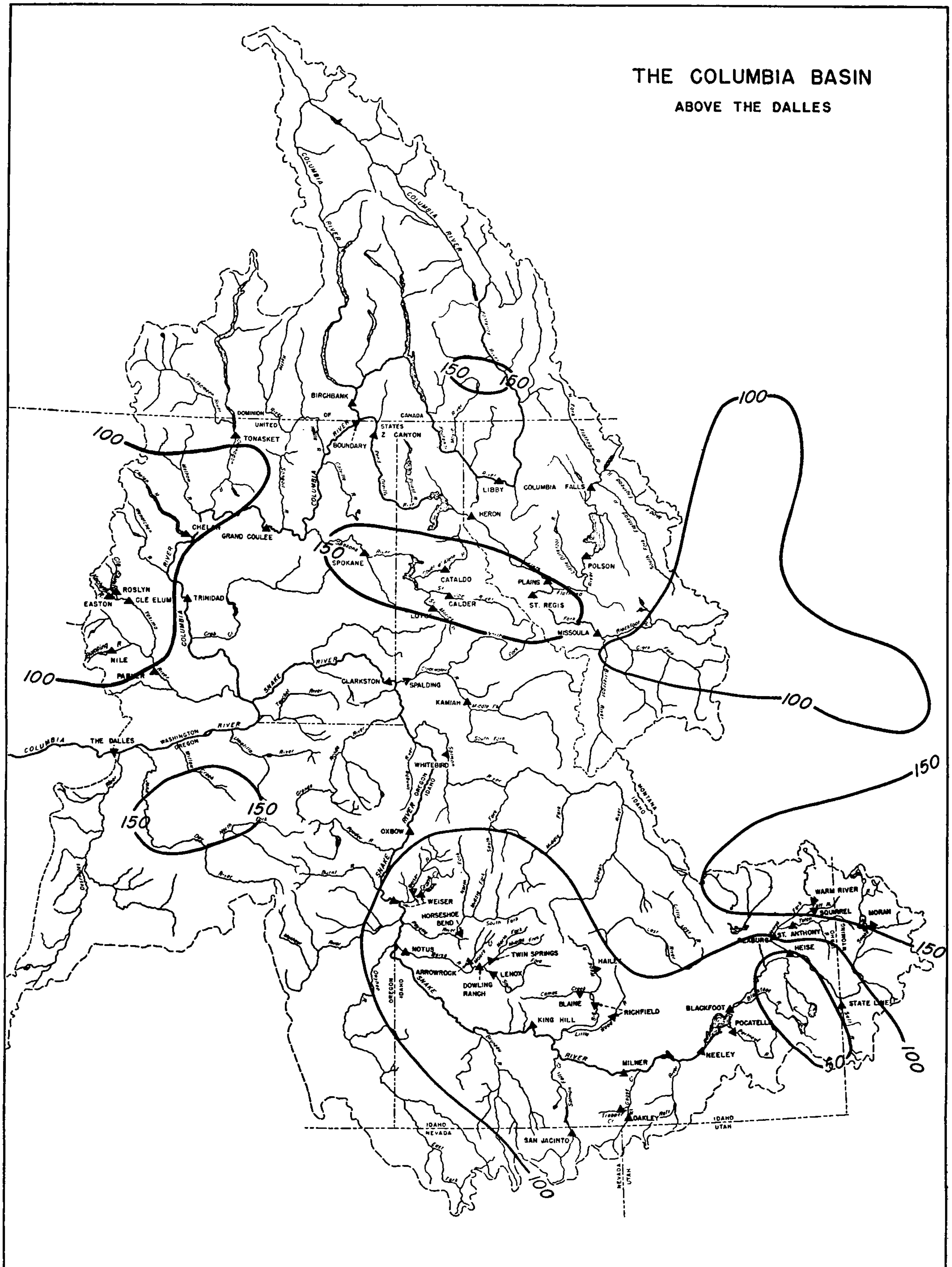


FIGURE 2.—Map showing isolines of precipitation in percent of normal over the Columbia Basin from October 1, 1947 to April 30, 1948.

METEOROLOGICAL CONDITIONS CONTRIBUTING TO FLOOD OF 1948

WINTER AND SPRING CONDITIONS

The weather during the winter and spring of 1947–48 fulfilled all the specifications for a major flood in the Columbia Basin. By April of 1948 the precipitation accumulated since October was in general above normal as the result of unusually frequent cyclonic passages over the region, with snow pack also above normal due to prevailing low temperatures. Precipitation in percent of normal over the basin from October 1, 1947, through April 30, 1948, is given in figure 2. With the exception of the Snake River Basin, precipitation averaged well above normal, with as much as 157 percent of normal at Superior, Mont., in the upper Columbia Basin. The Snake River normally contributes very little to the Columbia flows due to the geological character of the basin and the heavy diversion for irrigation purposes.

Temperatures during the winter and spring months were relatively low, thus permitting more than the usual portion of the winter and spring precipitation to remain on the basin as snow. This was especially true of the spring months. Figure 3 shows the average weekly temperatures and the average total weekly precipitation at a selected group of stations in the basin from March through June. With the exception of one week in April the temperatures were below normal until about May 15. Normal melting during April and early May was retarded and the accumulation of snow on the ground accentuated by late heavy snows.

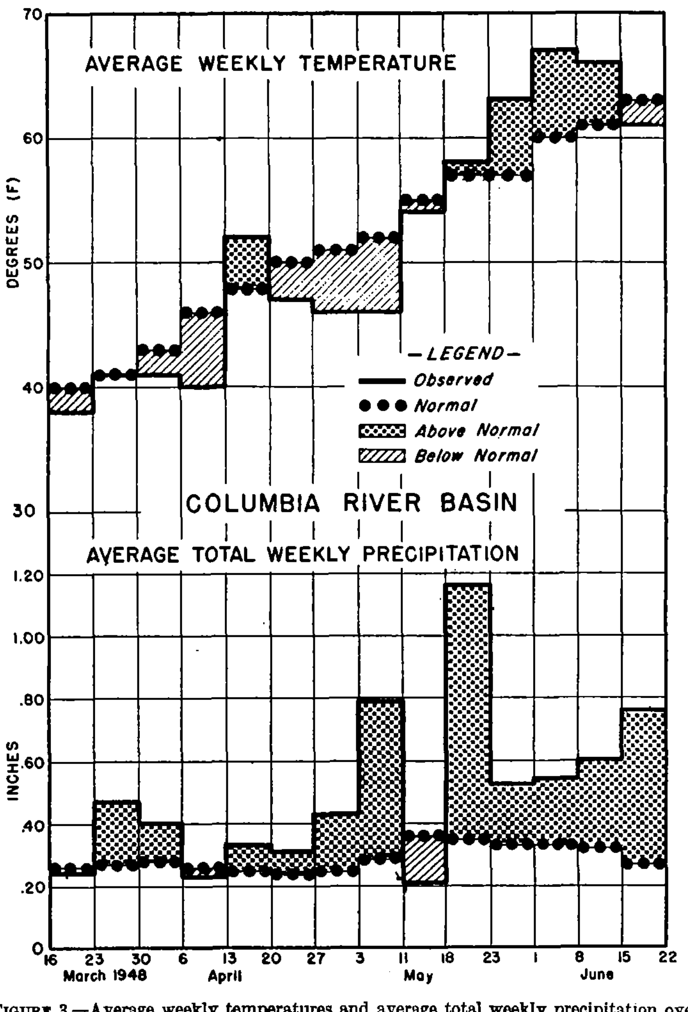


FIGURE 3.—Average weekly temperatures and average total weekly precipitation over the Columbia Basin from March 16 to June 22, 1948. The normal values have not been smoothed.

CRITICAL PERIOD CONDITIONS

The magnitude of the flood that followed, however depended to a large extent on the weather of the period from the middle of April to the middle of June. This period can be divided into two parts, both with above normal precipitation, but the first half, mid-April to mid-May, had below normal temperatures while the second half, mid-May to mid-June, had above normal temperatures. The two parts of the critical period were so consistently different in character that the differences appear clearly even in mean flow patterns such as those of the mean 700-mb. height contour charts regularly prepared by the Extended Forecast Section of the Weather Bureau.

The chart for the cold half of the critical period, mid April to mid-May, showed air being brought to the basin from about latitude 60° N. although its normal trajectory is from about latitude 40° N. Though the air entered the basin from the west and southwest, it had been brought only a short distance cyclonically around a low-pressure center in the Gulf of Alaska. It was thus not only cold but also unstable as a result of its short trajectory over water. Heavier-than-normal precipitation was produced when the air was lifted by the north-south mountain ridges of the basin, with resulting precipitation mostly in the form of snow because of the low temperatures.

The mean map for the warm half of the critical period, mid-May to mid-June, showed a marked change in flow pattern. A Low was established off northern California and a high pressure ridge over the midcontinent. Between them there was a flow from the south and southeast directly over the basin, from latitudes 25°–30° N. instead of the usual latitudes 35°–40° N. Brought from so far south, its probable source the Gulf of Mexico, the air was warm and moist. Cyclonic flow as it approached the Columbia Basin, increased its instability and favored shower and thunderstorm activity. The air was thus in such a condition that even a small amount of lift or insolational heating would cause it to rise to high elevations, cool to the condensation point and precipitate—now as rain rather than snow because of the accompanying high temperatures.

Two maps (figs. 4 and 5), with concurrent temperatures plotted, have been selected to show typical rather than mean flow patterns during the contrasting periods. They are for the 850-mb. surface, at approximately 5,000 feet, which can be taken as the mean elevation of the basin. On the map for May 1 (fig. 4), about the middle of the cold period, flow into the basin is from the northwest, with temperatures near or below freezing throughout the basin. The map for May 27 (fig. 5), about the middle of the warm period, shows the flow into the basin from the south or southeast and temperatures in the basin of the order of 70° F., indicating temperatures near 90° F. at sea level and in the 50's at 10,000 feet—far above freezing throughout the range of altitudes.

There were interesting day-to-day variations from the synoptic patterns presented. In the cold period, some days were comparatively dry, others comparatively wet. In both cases, as in the mean pattern, a Low was centered north of latitude 45° N. and east of longitude 140° W.

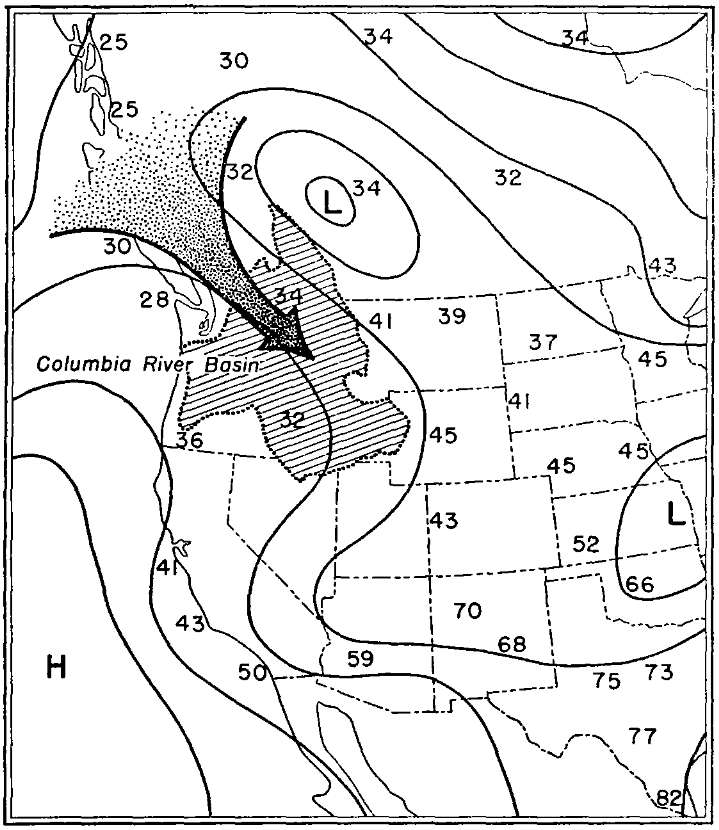


FIGURE 4.—850-mb. height contour chart showing air flow and temperatures (° F.) 1900 P. S. T., May 1, 1948.

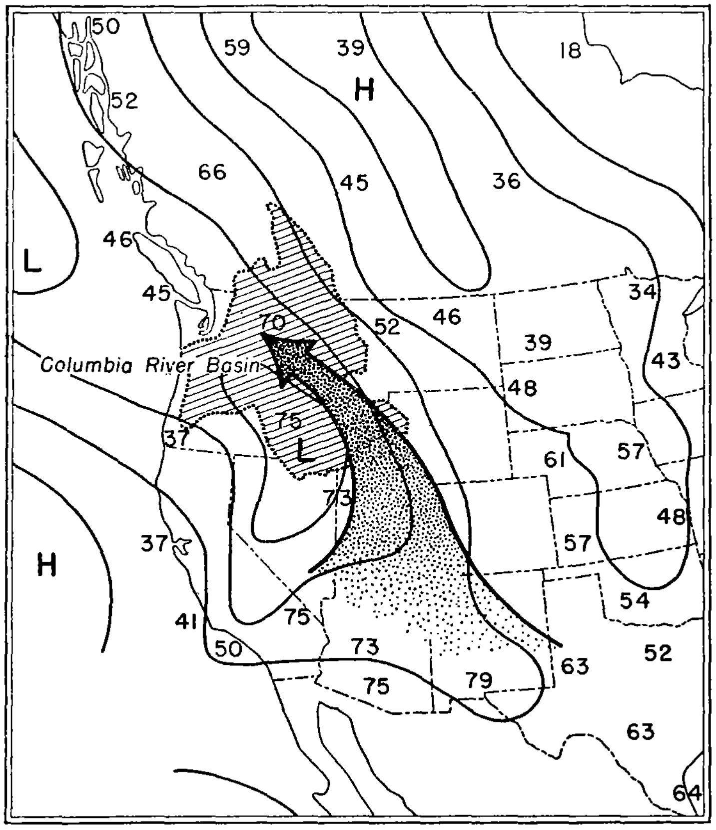


FIGURE 5.—850-mb. height contour chart showing air flow and temperatures (° F.), 1900 P. S. T., May 27, 1948.

When the Low was off the coast, the flow over the basin was from the southwest, cold but with heavy precipitation. When the Low was inland, flow was from the northwest, still cold but with less precipitation. An important difference was the greater moisture content of the current from the southwest and its instability due to short water trajectory. During the warm period, the Low was characteristically centered farther south, near northern California. When off the coast, its induced flow from the south brought air of great moisture content to the basin, with resultant heavy rainfall. As the Low moved eastward into the continent, the northward flow was more and more from a continental source, bringing somewhat warmer but drier air, with lesser rains resulting.

COMBINATION OF FLOOD-PRODUCING FACTORS

With the snow pack already of above-normal depth in early April, the two periods described provided an unusually efficient combination of factors to intensify the flood flow. During the cold period the snowfall was heavy while the cold temperatures prevented the melting that normally begins in this period. Thus the early snow-melt contribution, ordinarily discharged from the southern tributaries and carried out to sea before the arrival of snow-melt discharge from the upper Columbia, was retarded. When the warm period came, melting took place over the entire basin simultaneously, increasing the snow-melt discharge at the mouth. To the snow-melt was added the runoff from concurrent rainfall.

Precipitation data in percent of normal over the Columbia Basin during May and June are given in figure 6. The amounts were generally excessive, except in the Snake River Basin, with amounts as much as 440 percent of normal over the main Columbia just above the Snake and over 200 percent of normal in much of the basin. It was above normal from March 16 to June 22 except for 3 weeks, as shown in figure 3. During the first half of May, precipitation was largely in the form of snow, and during the last half, mainly in the form of rain. Heavy run-off occurred from the rain at the same time that run-off from melting snow was arriving from the extreme eastern and northern headwaters. Reservoirs in the area had very little effect in reducing flood crests as they are largely for irrigation and were generally filled by the time this rain occurred.

Part of the unusual sequence of circumstances combining to make this flood of the first magnitude is illustrated in the graphs of the variation of temperature, from May 1 to June 15, at 5,000 feet at two radiosonde stations in the basin, Spokane and Boise (fig. 7). The sloping line shows the normal trend of the median temperature (the temperature exceeded 50 percent of the time). Horizontal lines show the extreme maximum and minimum observed temperatures for May at this level, for the period of upper-air record through 1948. The dots show the actual temperatures observed during 1948. Most of the 1948 observations fall below the median during the first half of May and above the median thereafter. Furthermore, the observed May 1948 temperatures include the extremes of record at Boise and closely approach the extremes at Spokane—with the lowest observed at the beginning of the month and with the highest observed at the end of the month, at each station. The abruptness of such a change emphasizes the infrequency of the combination of events which produced the 1948 flood.

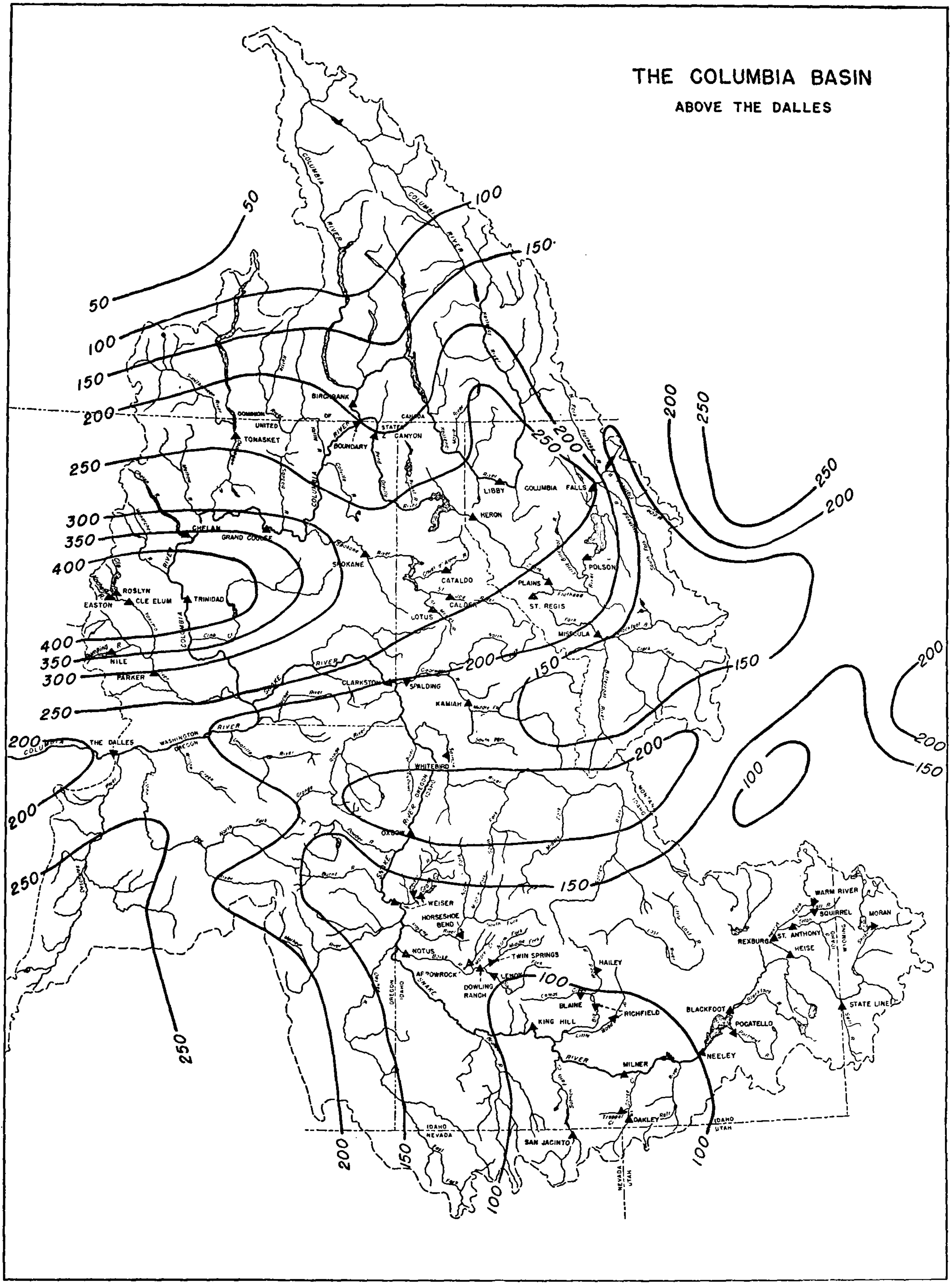
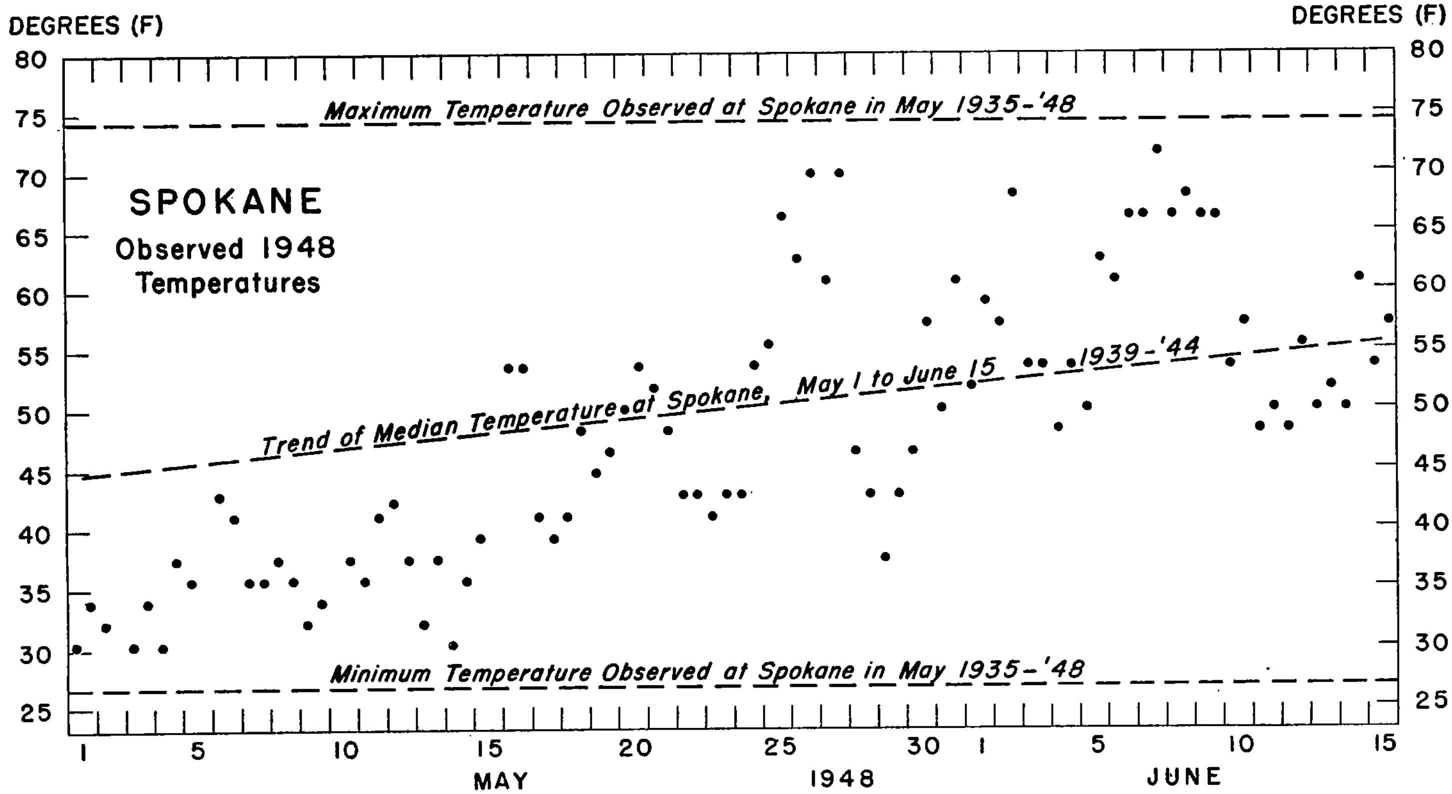


FIGURE 6.—Map showing isolines of precipitation in percent of normal over the Columbia Basin from May 1 to June 30, 1948.



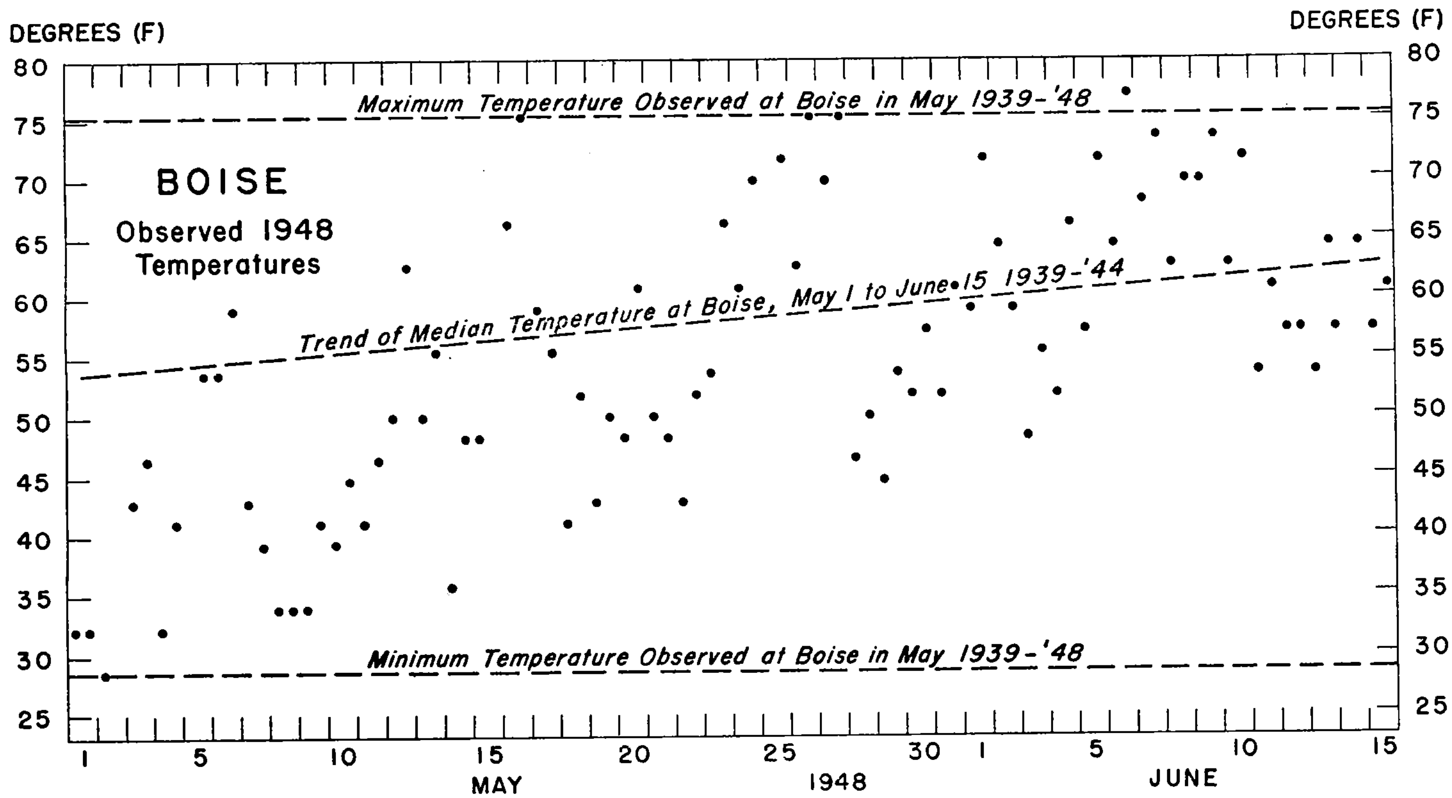


FIGURE 7.—5,000 ft. temperatures at Spokane and Boise. Dots show observed temperatures, May 1 to June 15, 1948.

TABLE 1.—*Duration and crests of 1948 Columbia Basin flood*

River and Station	Dates above flood stage		Duration of flood (days)	Flood stage (feet)	Crest		Previous maximum of record	
	From—	To—			Stage (feet)	Date	Stage (feet)	Date
Kootenai:								
Libby, Mont	May 25	May 29	5	18	19.9	May 28	20.7	June 21, 1916.
Bonners Ferry, Idaho	May 23	June 12	21	31	35.3	do	32.7 [1] 34.2	June 22, 1916. June 1894.
Flathead:								
Columbia Falls, Mont	May 19	June 9	22	13.2	19.1	May 23	[1] 22.7 17.3	Do. June 1, 1923.
Somers, Mont	May 26	June 21	27	93.0	96.0	June 6–8	96.3	June 19, 1933.
Polson, Mont	May 25	June 22	29	15.6	19.2	June 6	17.1	May 29, 30, 1928.
Clark Fork: St. Regis, Mont	May 21	June 10	21	17	20.0	May 24	19.1	May 30, 31, 1913.
St. Joe:								
Calder, Idaho	May 18	June 4	18	87	89.0	May 28	93.1	Apr. 18, 1938.
St. Maries, Idaho	May 19	June 7	20	35	39.2	May 30		
Coeur d'Alene:								
Cataldo, Idaho	May 8 May 13	May 10 May 31	22	40	47.6	May 21	56.9	Dec. 22, 23, 1933.
Coeur d'Alene Lake, Idaho	May 1	June 16	47	30	36.0	May 30	39.05	Dec. 25, 1933.
Spokane: Spokane, Wash	May 23	June 7	16	27	28.4	May 31		May 31, 1894.
Salmon: White Bird, Idaho					32.5 33.0	May 29 June 3	[1] 37.5 31.2	June 1894. June 9, 1921.
Clearwater:								
Kamiah, Idaho	May 20	June 10	22	14	19.2 15.0	May 29 June 8	16.5	June 10, 1933.
Spalding, Idaho	May 28	May 29	2		23.8	May 29	[1] 25.6 23.2	Jan. 5, 1928. Dec. 23, 1933.
Snake: Lewiston, Idaho	May 29	May 29	1	22	22.8	May 29	26.0	June 6, 1894.
Willamette: Portland, Oreg	May 22	July 3	43	18	29.95 29.7 30.0	June 1 June 6 June 14	33.0	June 7, 1894.
Columbia:								
Boundary, Wash	May 27	July 2	37	32	45.0	June 11–12	34.0	June 27, 28, 1938.
Trinidad, Wash	May 21	July 11	52		56.9 59.4	May 30 June 12	[1] 61.0 52.5	June 1894. June 23, 1933.
Umatilla, Oreg	May 27	June 21	26	25	30.5 29.7	May 30–31 June 11	34.5	June 5, 1894.
Celilo, Oreg	May 22	July 2	42		34.6 33.7	May 31 June 12	[1] 40.1 23.4	June 6, 1894. June 18, 19, 1903.
Vancouver, Wash	May 19	July 8	51	15	30.2 30.0 30.2	June 1 June 6 June 13, 14	[2] 34.4 25.5	June 7, 1894. June 19, 1933.

[1] High water mark. [2] Estimated from Portland stage.

FLOOD OF 1948

The combination of all these factors and the particular order in which they occurred brought about one of the worst floods ever recorded in the Columbia River system. Table 1 gives a résumé of duration of flood and height of crests on the Columbia and its tributaries, in comparison with previous records. Record or near-record stages occurred on all reaches of the Columbia.

UPPER COLUMBIA

The flow in the streams of the upper Columbia Basin was very low during the first 4 months of 1948 despite above-normal precipitation and a heavy snow pack. During the first half of May, the Kootenai River at Bonners Ferry, Idaho, averaged about one-half bank-full stage. It rose rapidly with the onset of warm weather, rising from 19.3 feet on the 19th to above bank-full stage on the 23d. Six days later it reached 35.2 feet, the highest stage of record. The flood hydrograph is illustrated in figure 8 along with other important flood hydrographs in the Columbia Basin.

The Kootenai River Valley is divided into about 15 reclamation districts consisting of nearly 40,000 acres of fertile farm land. These reclamation districts vary in size from 1,000 acres or less to as much as 5,000 acres or more, with protective dikes built around each so as to prevent neighboring districts from flooding in the event the river overflows one subdivision. As bank-full stage was reached at Bonners Ferry, the dike surrounding Reclamation District No. 7 crumbled, flooding 2,300 acres of wheat land. As the dikes failed every Reclamation District in the valley was flooded to depths of 10 to 15 feet.

Approximately 160,000 acres were inundated along the major tributaries of the upper Columbia River (Kootenai, Clark, and Spokane Rivers) causing severe damage to farm lands, crops, buildings, fences, highways, and railroads.

SNAKE RIVER SYSTEM

River stages were seasonably moderate, on the lower Snake, Salmon, and Clearwater Rivers throughout the first half of May, with some higher stages at irregular intervals. Gradual, almost steady rises took place throughout the Snake River system during the latter half of the month and moderate to severe flooding occurred during the last decade in May and the first week of June. The secondary crests in June were considerably lower than the major ones in May except on the lower Salmon where it exceeded the previous maximum recorded stage for the second time in a week. Little control was afforded by irrigation dams as the principal reservoir holdings were already at or near capacity levels. Serious flood conditions were developed rapidly along the lower Snake, lower Clearwater, and lower Salmon from May 26th through the 30th. The most rapid rises occurred on the 28th and 29th after the high temperatures of the 27th and the excessive rainfall over the middle Clearwater and Salmon drainage areas on the 28th and 29th. The greatest 24-hour rise (3 feet) was observed at Kamiah, Idaho, on the Clearwater on the morning of the 29th when the previous maximum stage of record was exceeded. The Snake River exceeded bank-full stage near Menan, Idaho, about June 1, inundating farm lands in the area until about the 20th. The greatest flooding occurred on June 10, when 3,000 to 5,000 acres were under water.

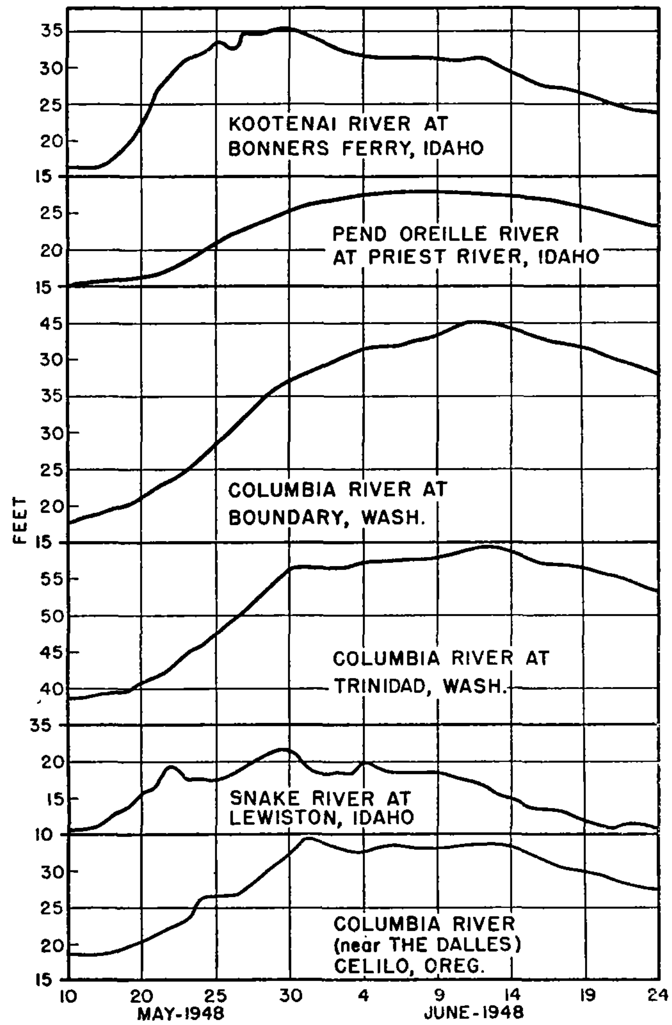


FIGURE 8.—Flood stage hydrographs for selected stations, May 10 to June 24, 1948.

Heaviest monetary loss apparently resulted from flooding of the bottom lands from Spalding to Lewiston, Idaho, and from damage to installations in the vicinity of Lewiston. Highway 95 from Riggins to White Bird, Idaho, was severely damaged.

LOWER COLUMBIA

Flooding began on the Columbia at Vancouver, Wash., on May 19, and on the Willamette at Portland, Oreg., 3 days later due to backwater from the Columbia. At Portland, the stage rose steadily from May 16 until the afternoon of June 1, except for slight fluctuations on May 18, and May 30, to the highest stage of record since the great flood of 1894. The slight fall on May 30 was due to the breaking of the Denver Avenue dike and the flooding of Vanport, Oreg. The failure of the railroad fill which served as a levee at Vanport, a war-born housing development with a population of 18,700 at the north edge of Portland, allowed flood waters to pour over the city completely destroying it.

The second crest on June 6 at Portland was slightly lower than the first, with the third crest of 30.0 feet on June 13–14 the highest. The critical feature of the flood, in addition to the extremely high stages, was its long duration, above-flood stage continuing 43 days at Portland, Oreg., and 51 days at Vancouver, Wash. According to the U. S. Geological Survey the peak flow of the Columbia River near The Dalles, Oreg. (a short distance east of Portland), was 1,010,000 cubic feet per second on May 31, a rate equal to about 450,000,000 gallons per minute. A flow of over 900,000 cubic feet per second was sustained for a period of about 17 days.

The Pope and Talbot Company terminal dock and warehouse on the river side of the Harbor Drive just above the Broadway Bridge in Portland were flooded. Numerous other docks and terminals at cities along navigable portions of the Columbia and lower Willamette were also inundated. Shipping and river traffic (movement of ships) were entirely prohibited for several days. The high water reached a depth of several feet on the first floors in the Union Stock Yards area after the failure of the Denver Avenue dike.

Although the railway yards around the Union Depot were inundated, flooding of the Union Station building was prevented by sand bagging and hurriedly constructed dikes. Flood waters rose above the doors on freight cars in the North Portland Yards on both sides of the Willamette River.

Highways and railways were flooded in addition to the flooding of the drainage districts. Both highway and rail traffic northward from Portland, Oreg., to Seattle, Wash., and eastward up the Columbia Gorge were considerably hampered or curtailed over the main route for a period of 10 days to 2 weeks. Industrial plants located along the river were flooded and severely damaged. Truck farms and almost all business establishments, shipyards, etc., along the lower Willamette or middle and lower Columbia were inundated and severely damaged.

Crews in most drainage districts worked continuously day and night to reinforce dikes or raise their height. This provided additional time for the evacuation of people, removal of livestock to higher ground, and the saving of personal effects.

Information on damages resulting from the flood is incomplete. Briefly, the approximate cost of the 1948 flood was as follows: More than a score of lives lost; more than 100 million dollars in damages; more than 700 homes destroyed (490 were government-owned and contained 6,809 dwelling units), with 4,480 more homes badly damaged; 38,500 people temporarily homeless; 53,500 persons given emergency care by the Red Cross; hundreds of animals lost; many bridges destroyed; many miles of roads and dikes destroyed with many more damaged; thousands of acres of crops lost; thousands of acres of topsoil gone; several towns almost wiped off the map, with the city of Vanport, Oreg., completely destroyed; much damage to streets, sewers, water systems, power lines, and telephone networks; serious interruption to normal activities and extended loss of use of such facilities as the main line of a transcontinental railroad and some major airports.

COMPARISON WITH 1894 FLOOD

Although the flood of 1948 was the most destructive of record, the volume of water discharged by the Columbia was not as great as that of 1894. The peak flow near The Dalles, Oreg., was 1,010,000 cubic feet per second on May 31, 1948 as compared with 1,240,000 cubic feet per second in June 1894 at the same place. Also the antecedent flow in 1894 was greater. A comparison of the hydrographs for Umatilla and Portland, Oreg., for the 2 floods is given in figures 9 and 10, respectively.

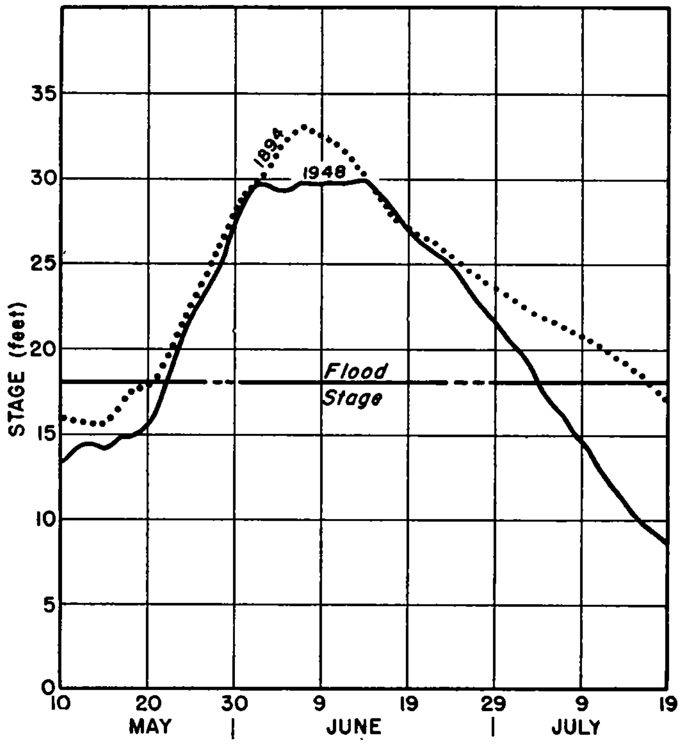


FIGURE 9.—Hydrograph at Umatilla, Oreg., May 10 to July 19, 1894 and 1948.

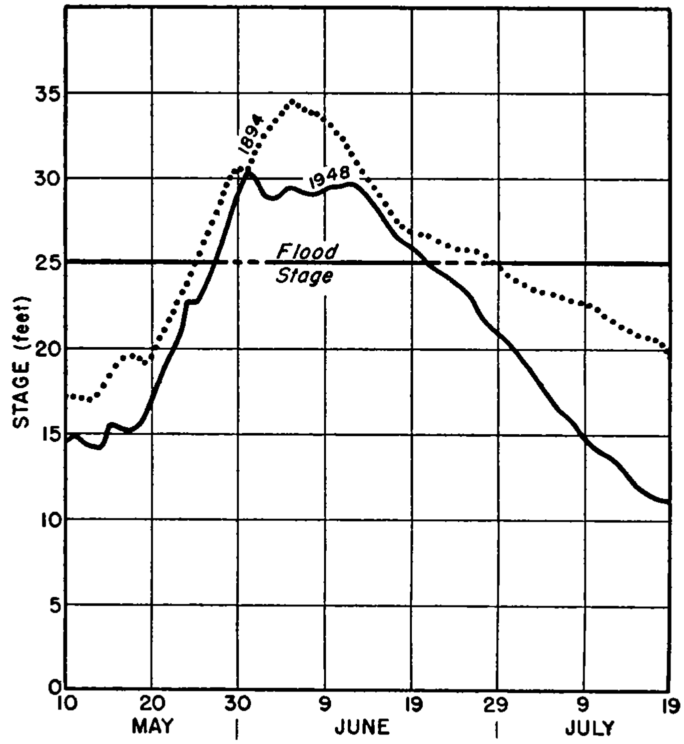


FIGURE 10.—Hydrograph at Portland, Oreg., May 10 to July 19, 1894 and 1948.

Weather conditions were somewhat different in the 2 seasons. Precipitation was much heavier during the winter of 1893–94 than in the winter of 1947–48. Therefore a heavier snow pack was available for runoff in 1894. Also, the spring season of 1894 was warmer and drier than the early months of 1948, resulting in an earlier runoff than in 1948. Table 2 shows the precipitation amounts for May 1894 and May 1948 over the Columbia Basin.

TABLE 2.—*Comparative precipitation, Columbia River Basin, May 1894 and May 1948*

Basin and station	Precipitation (inches)	
	May 1894	May 1948
Snake:		
Baker, Oreg.	2.43	1.80
Boise, Idaho	2.08	1.09
Walla Walla, Wash.	1.01	3.13
Upper Columbia:		
Missoula, Mont.	1.43	3.96
Spokane, Wash.	1.01	5.74
Lower Columbia:		
Portland, Oreg.	1.09	3.88
Roseburg, Oreg.	1.73	2.93
Seattle, Wash.	1.99	4.59

CONCLUSION

This study of the 1948 flood shows that the heavy rainfall and high temperature of May and June following a winter and spring favorable for high accumulation of snow were the final critical factors in producing a flood of such duration and extent. The snow pack was not as heavy as that of 1894, and probably would not have produced such a disastrous flood of itself. The addition of heavy runoff from excessive rainfall to the late season snow melt was enough to tip the scales in the direction of high river stages and serious loss of life and property.

ACKNOWLEDGMENTS

Special acknowledgment is due Mr. Bennett Swenson, Chief of the River Services Section, for valuable suggestions and assistance in the preparation of this report, A. L. Shands of the Hydrometeorological Section for preparation of material on meteorology, and others of the Division of Climatological and Hydrologic Services for their valuable contributions. Acknowledgment is also due the Regional Office Seattle, Wash., and other field offices (Portland, Oreg., Spokane, Wash., Boise, Idaho, and Wenatchee, Wash.) for their excellent reports on the flood.